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| EXAMINER | |
| MUTSCHLER, BRIAN L | |
| ART UNIT | PAPER NUMBER |

1753

DATE MAILED: 10/09/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/760,884

Applicant(s)

ANDRICACOS ET AL.

Examiner

Brian L. Mutschler

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 02 September 2003.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 10-23 and 29-31 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 10-23 and 29-31 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____
- 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other:

DETAILED ACTION

Comments

1. The objections to the specifications have been overcome by Applicant's amendment.
2. The rejection of claims 10-23 and 29-31 under 35 U.S.C. § 112, 1st paragraph, has been overcome by Applicant's amendment to the claims, incorporating limitations enabled by the specification.
3. The rejection of claims 17, 23 and 31 under 35 U.S.C. § 112, 2nd paragraph, has been overcome by Applicant's amendment.
4. The rejection of claims 10-14, 16, 18-20 and 29-31 under 35 U.S.C. § 103 over GILTON et al. in view of WOO et al. has been overcome by Applicant's amendment. GILTON et al. teaches a current density of less than 1 mA/cm², which is less than the 5-25 mA/cm² current density now recited. The same applies to the rejection of claims 15 and 21-23 under 35 U.S.C. § 103 over GILTON et al. in view of WOO et al. and TING et al.

Specification

5. The disclosure is objected to because of the following informalities:
 - a. On page 5 at line 2, please change both occurrences of "μA/cm" to --mA/cm²--;Appropriate correction is required.

Claim Rejections - 35 USC § 112

6. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

7. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

8. Claim 30 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 30 recites the limitation "wherein the depositing of copper is carried out at a rate of about 5 to about 25 $\mu\text{A}/\text{cm}^2$ " in lines 1-2. This limitation is indefinite because it claims a broader range than claim 29, from which claim 30 depends. Since the units are identical, it appears that the rate of deposition is the same as the current density. Since the units are identical to the claimed current density, the limitations regarding the rate of deposition are indefinite. A narrow range cannot be further limited by a broader range.

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

10. Claims 10-14, 16-20 and 29-31 are rejected under 35 U.S.C. 103(a) as being unpatentable over WO 99/47731, herein referred to as WO '731, in view of LANDAU (U.S. Pat. No. 6,261,433).

Regarding claim 10, WO '731 discloses a method for fabricating electronic structures wherein a barrier layer **10** is formed over an insulating layer **8** having trenches **5** or vias (lines of metallization) formed therein (fig. 2A; page 12 to page 13). Copper is electroplated directly onto the barrier layer **10** (page 12, line 5). The electroplating bath is comprised of copper sulfate, as a source of cupric ions, and a complexing agent (page 16). The bath is maintained at a pH of at least 9.0 and can have a pH of 5-13 (page 17). The current density used for electroplating "can be 1 to 5 milliamps/cm²", which contains the endpoint of the claimed range (page 18).

Regarding claim 13, the barrier layer **10** can be made of titanium nitride or tantalum nitride (page 12).

Regarding claim 14, the thickness of the barrier layer is approximately 100 to 300 Angstroms (10 to 30 nm), which is greater than 4 nm (page 13).

Regarding claim 16, the dielectric **8** is silicon dioxide (page 13).

Regarding claim 18, the temperature of the electroplating bath can be within a range of 20 to 35°C (page 18).

Regarding claim 19, copper sulfate is used as the source of cupric ions and EDTA is used as a complexing agent (page 17).

Regarding claim 20, potassium hydroxide or sodium hydroxide may be used to control the pH (page 17).

The method disclosed by WO '731 differs from the instant invention because WO '731 does not disclose the following:

- a. Lithographically defining and forming recesses for lines and/or vias, as recited in claim 10;
- b. A current density of greater than 5 mA/cm² to 25 mA/cm², as recited in claim 10;
- c. Copper deposited to provide a thickness of about 10 nm to about 100 nm, as recited in claim 11;
- d. Copper deposited to provide a thickness of about 20 nm to about 50 nm, as recited in claim 12;
- e. The recesses have an aspect ratio of greater than 3:1, as recited in claim 17;
- f. The current density is about 10 to about 20 mA/cm², as recited in claim 29; and
- g. The depositing of the copper is carried out at a rate of about 5 to about 25 mA/cm², as recited in claims 30 and 31.

Regarding claims 10 and 29-31, WO '731 discloses that the current density can be "1 to 5 milliamps/cm² (page 18). LANDAU discloses a method for fabricating electronic structures comprising the step of forming an insulating layer **16** and forming recesses defining vias using a lithographic technique (fig. 1A-1E; col. 2, lines 34-57). A barrier layer **20** is formed on the insulating layer **16** and copper **22** is electroplated on top of the barrier layer **20** (col. 2, line 58 to col. 3, line 26). LANDAU teaches

"plating/deposition is accomplished with a relatively low current density for a relatively long interval because low current density promotes deposition uniformity" (col. 15, lines 48-63). LANDAU discloses the use of current densities of about 5 mA/cm² to about 40 mA/cm² (col. 16, lines 21-24). The current density is chosen to provide the desired uniformity.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have used lithographic technique for forming the recesses in the insulating layer of WO '731 as taught by LANDAU because lithographic techniques efficiently and accurately form patterns in insulating layers.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the current density in the method of WO '731 to use a current density of about 5 mA/cm² to about 25 mA/cm² because LANDAU teaches that the uniformity of the deposited copper can be controlled by the current density and that low current densities promote greater uniformity.

Regarding claims 11 and 12, the amount of copper that is plated is proportional to how long the method is applied with the current density that is used. As such, the thickness of the deposited layer is a variable controlled by the user. It is the overall method steps that are given patentable weight and not the structural limitations thereof unless the structural limitations materially alter the overall method (*In re Leesona Corp.*, 185 USPQ 156; *Ex parte Pfeiffer*, 1962 CD 408; *Ex parte Kangas*, 125 USPQ 419; *Ex parte Foreman*, 1924 CD 47; *Ex parte Nelson et al*, 82 USPQ 115; *In re Winder*, 1957

CD 175; *Ex parte Hart*, 117 USPQ 193). It does not appear that the overall method of WO '731 is significantly altered as a function of the thickness of the electrodeposited layer. The method disclosed by WO '731 and the method of the instant invention are both processes for forming high aspect ratio damascene structures. As such, the thickness of the thus formed structure appears to be a matter of designer choice and optimization given the art known and technology definitions of size parameters of "high-aspect" microstructures. The electrolytic deposition of filling the recess is allowed to occur until a sufficient thickness is deposited.

Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have used the method of WO '731 to deposit copper to a desired thickness such as 10 nm to 30 nm or more, as taught by WOO et al.

Regarding claim 17, the method of WO '731 is used to fill vias and trenches 5 with copper. However, the aspect ratios of the microstructures are not disclosed. LANDAU teaches that the method of electroplating copper in vias can be used for filling structures having aspect ratios exceeding 4:1 (col. 1, lines 34-39).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have used the method of WO '731 to fill vias having aspect ratios exceeding 3:1 because LANDAU teaches that the plating method can be used to plate vias having aspect ratios exceeding 4:1.

11. Claims 15 and 21-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over WO 99/47731 in view of LANDAU (U.S. Pat. No. 6,261,433), as applied above to claims 10-14, 16-20 and 29-31, and further in view of TING et al. (U.S. Pat. No. 5,969,422).

WO '731 and LANDAU describe a method having the limitations recited in claims 10-14, 16-20 and 29-31 of the instant invention, as explained above in section 10.

The method described by WO '731 and LANDAU differs from the instant invention because they do not disclose the following:

- a. The barrier layer is tungsten, as recited in claim 15;
- b. The electroplating bath further comprises a stabilizer and a surfactant, as recited in claim 21;
- c. The stabilizer is 2,2'-bipyridyl, as recited in claim 22; and
- d. The electroplating bath further comprises cyanide ions, as recited in claim 23.

Regarding claim 15, TING et al. disclose a method for forming copper interconnect structures in electronic devices by plating copper over a barrier layer **30**, which is formed on an insulating layer **11** (fig. 3; col. 9, lines 52-65). The barrier layer **30** can be made of a material including tantalum, titanium, tungsten, tungsten nitride or other materials (col. 7, lines 29-31).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the barrier layer metal in the method of WO '731 and LANDAU to use tungsten as taught by TING et al. because tungsten is an

equivalent barrier metal to other tantalum/titanium/tungsten/nitride materials disclosed by WO '731 and LANDAU and would be expected function equivalently.

Regarding claims 21-23, TING et al. discloses the use of an electroplating bath comprising copper sulfate, EDTA, potassium hydroxide, "RHODAFAC RE 610 or polyethylene glycol as a surfactant and wetting agent, and ammonium cyanide or 2,2'-dipyridyl as a stabilizer" (col. 10, lines 42-55).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the electroplating bath in the method of WO '731 and LANDAU to use surfactants and stabilizers as taught by TING et al. because TING et al. have shown that the use of a stabilizer and surfactant in the electroplating bath would have promoted ductility and prevented the formation of nodules in the electroplated copper deposit, thus significantly advancing void-less fill of the via structure.

12. Claim 17 is rejected under 35 U.S.C. 103(a) as being unpatentable over GILTON et al. (U.S. Pat. No. 5,151,168) in view of WOO et al. (U.S. Pat. No. 6,440,289), as applied above to claims 10-14, 16, 18-20 and 29-31, and further in view of LANDAU (U.S. Pat. No. 6,261,433).

GILTON et al. and WOO et al. describe a method having the limitations recited in claims 10-14, 16, 18-20 and 29-31 of the instant application, as explained above in section 10. GILTON et al. further disclose, "the plating process will automatically fill

contact/via openings to a uniform thickness which is independent of the depth of contact/via openings **13**" (col. 5, lines 32-35).

The method described by GILTON et al. and WOO et al. differs from the instant invention because they do not disclose the recesses having an aspect ratio of greater than 3:1.

LANDAU teaches that the method of electroplating copper in vias is used for filling structures having aspect ratios exceeding 4:1 (col. 1, lines 34-39).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have used the method of GILTON et al. and WOO et al. to fill vias having aspect ratios exceeding 3:1 because LANDAU teaches that the plating method is used to plate vias having aspect ratios exceeding 4:1.

Response to Arguments

13. Applicant's arguments filed September 2, 2003, have been fully considered but they are not persuasive.

14. Regarding the rejection of claims 10-14, 16-20 and 29-31 over Chen (WO 99/47731) in view of Landau (U.S. Pat. No. 6,261,433), Applicant has argued that the instant invention relates to a method of plating copper directly onto a barrier layer and Chen and Landau plate copper onto a seed layer.

15. This argument is not persuasive because Chen clearly teaches "an alkaline electrolytic copper bath is used to electroplate copper onto a seed layer, electroplate copper directly onto a barrier layer material, or enhance an ultra-thin copper seed layer

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which has been deposited on the barrier layer" (see page 12, first paragraph).

Therefore, Chen teaches electroplating copper directly on either a barrier layer, as recited in the instant claims, or a seed layer.

Conclusion

16. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

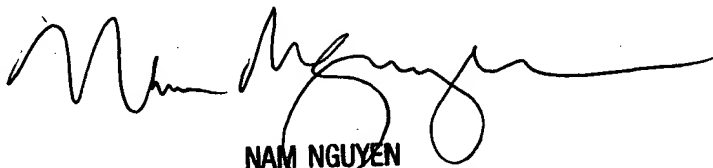
A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Brian L. Mutschler whose telephone number is (703) 305-0180. The examiner can normally be reached on Monday-Friday from 7:30am to 4:00pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on (703) 308-3322. The fax phone number for the organization where this application or proceeding is assigned is (703) 872-9306.

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Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.

A handwritten signature in black ink, appearing to read 'Nam Nguyen', with a long horizontal flourish extending to the right.

blm
October 7, 2003

NAM NGUYEN
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 1700